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Evaluation of treatment outcomes in the graduate orthodontic clinic at Sefako Makgatho University using the American board of orthodontics cast and radiographic examination

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EVALUATION OF TREATMENT OUTCOMES IN THE GRADUATE ORTHODONTIC CLINIC AT SEFAKO MAKGATHO UNIVERSITY USING THE AMERICAN BOARD OF ORTHODONTICS CAST AND RADIOGRAPHIC EXAMINATION

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A research report submitted to the Faculty of Health Sciences, University of Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the Degree of Master of Dentistry in the branch of Orthodontics

2020

Declaration

I, Mathuraya Rangan, declare that this research report “Evaluation of treatment outcomes in the graduate orthodontic clinic at Sefako Makgatho Health Sciences University using the American Board of Orthodontics Cast and Radiographic Examination” is my own work. It is being submitted for the Degree of Master of Dentistry in the branch of Orthodontics at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

Dr Rangan

16th day of July 2020 in Pietermaritzburg

Dedication

In memory of my father

Vilasa Rangan

1951 – 2019

Thank you for believing in me, for your constant

encouragement, reassurance and support.

Thank you for empowering me with the tools necessary to endure this path.

I will be forever grateful.

Abstract

Introduction: Assessment of treatment outcomes is an important component of orthodontics. There are no clearly defined standardised criteria for the assessment of treatment outcomes in orthodontics in South Africa.

Objective: This study serves as an audit for the assessment of treatment results by postgraduate orthodontic students at Sefako Makgatho Health Sciences University (SMU).

Methodology: As a retrospective, descriptive, cross sectional study, all available post-treatment records of patients managed by registrars between 1 January 2011 and 31 December 2015 at SMU were graded using the American Board of Orthodontics (ABO) Cast and Radiographic Examination (CRE).

Results: Forty nine cases met the inclusion criteria. The average CRE score was below the acceptable range for ABO CRE with a median of 43. The Fishers exact test showed significant differences amongst the CRE scores of the registrars (p=0.00).

Conclusion: The need for postgraduate orthodontic training programmes within South Africa to implement a standardized method of assessing treatment outcomes is evident. The ABO CRE is a resourceful method of assessing the quality of treatment.

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I would like to thank the following persons for their invaluable contribution to my postgraduate journey:

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List of abbreviations and acronyms:

ABO	American Board of Orthodontics
CCA	Comprehensive Clinical Assessment
CMF	Case Management form
CMSA	College of Medicine South Africa
CRE	Cast and Radiographic Examination
DI	Discrepancy Index
GT (>)	Greater than
ICON	Index of Complexity, Outcome and Need
ICO	Improvement and Completion of Outcome Index
LT (<)	Less than
Md	Mandibular
Mx	Maxillary
OGS	Objective Grading System
PAR	Peer Assessment Rating
Pt	Point
SMU	Sefako Makgatho Health Sciences University
Wits	University of Witwatersrand
≤	Less than or equal to
≥	Greater than or equal to

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Chapter 1

Introduction and literature review

Orthodontic treatment endeavours to achieve proper alignment of the teeth and a stable, functional occlusion as well as excellent dental and facial aesthetics.[1] Several contributions from well-known orthodontists have aided clinicians in their attempts to create a universally accepted standard of classifying malocclusions which would enable the identification of deviations from the norm.[1–4]

Historically, Angle's molar classification and consideration of the overjet have been the criteria most commonly used to describe static occlusion. Angle defined the ideal Class I molar relationship as the mesio-buccal cusp of the maxillary first permanent molar occluding in the mesio-buccal groove of the mandibular first permanent molar.[2] This classification was enhanced by Andrews Six Keys of Occlusion.[3] Andrews focused on the molar relationship, crown angulation (mesio-distal tip) and bucco-lingual inclination (torque), tooth rotations and excess spacing of teeth, correct Curve of Spee and level gingival margin heights. This work has contributed significantly to the evaluation of treatment outcomes. A properly treated case should meet the criteria set down by Andrews.[3,4]

In 2000, Andrews introduced the concept of the six elements of oro-facial harmony which are universally accepted key factors necessary for the achievement of better facial balance.[4] This involved the identification of ideal arch characteristics with respect to the relationship between the teeth and the arches as well as the interaction between the arches themselves. Andrews identified optimal antero- posterior jaw relationships, jaw widths, jaw heights and chin prominence in addition to the fundamental six keys of occlusion, to be essential for the attainment of successful treatment outcomes.[4] This method of assessment serves as a comprehensive, universal tool in the diagnosis, classification and treatment of malocclusion with respect to the gingivae, alveolar processes as well as the roots of teeth.[4]

The contributions of both Angle[2] and Andrews[3,4] have provided the basis for the formulation of orthodontic indices which have facilitated the development of treatment objectives based on achieving an ideal, stable occlusion once all deviations from the norm have been corrected. It is now possible to clearly define the aetiology of the malocclusion.

Since the 1970's, several methods of assessing both the difficulty and the outcome of orthodontic treatment have been introduced into the practice of orthodontics.[5–13] Each new concept endeavoured to address previous limitations and improve upon the existing approaches. The indices that have gained major attention are the Peer Assessment Rating index (PAR),[6,7] the Index of Complexity, Outcome and Need (ICON),[8] the Discrepancy Index (DI)[9] and the Cast and Radiographic Examination (CRE).[10]

The PAR Index

In 1987, the PAR index was developed by a group of ten orthodontists representing the British Orthodontic Standards Working Party.[6] It was formulated in an attempt to provide a quantitative assessment of both the severity of the initial malocclusion and of the treatment outcome, using a single, standardised scale.[6,7] This was done by assessing over 200 models representing various pre-treatment and post-treatment occlusions.[6,9]

The PAR index can be used to assess malocclusion at any stage of treatment.[6] The various factors of malocclusion are scored on pre- and post-treatment plaster models using a PAR ruler. The factors considered are the antero-posterior, transverse and vertical irregularities affecting the occlusion, overjet, overbite, the centreline as well as the contact points.[6] The scoring starts at zero representing good alignment. As the level of irregularity in alignment and deviation from the norm worsens the score increases. The difference between the pre- and post-treatment score is indicative of the degree of improvement. A score of ten or less represents acceptable alignment and occlusion and five or less represents an ideal outcome of the completed treatment.[6]

As the PAR index is restricted to only assessing the occlusal aspects of the treatment,[13] it has been found to be more suited to assess treatment outcomes rather than treatment needs.[14] However, minor tooth discrepancies are overlooked as it does not adequately record incisor torque, posterior alignment and changes in arch dimensions.[14,15] The PAR index is thus not an ideal method of assessing treatment outcomes.[6,12,16,17]

The Index of Complexity, Outcomes and Need (ICON)

In 2000, Daniels and Richmond[8] conceptualised the ICON method based on the judgement of a panel of 97 international orthodontists regarding treatment need, treatment complexity, treatment improvement as well as treatment acceptability.[8] 240 initial models were reviewed regarding treatment need and 98 paired pre- and post-treatment models were used for the assessment of treatment outcomes.[8] Specific occlusal characteristics were identified and rated with the assistance of a tabulated scale according to the level of difficulty and degree of post-treatment outcomes.

The occlusal factors considered were aesthetics, crossbite, upper arch crowding, impacted teeth, antero-posterior interdigitation of the buccal segments as well as the vertical relationship of the anterior segment.[8]

Each occlusal factor was weighted and cases were scored accordingly. Pre-treatment and post-treatment scores were compared to assess the degree of improvement. An acceptable treated case would score less than 31. A score greater than or equal to 31 was deemed to be an unacceptable outcome.[8] The ICON was more accurate in the assessment of treatment needs compared to treatment outcomes.[8]

The aforementioned two indices are not precise, and their validity and reliability have not been established.[8,9,14,16] Given these shortcomings, they would not provide a suitable method of comprehensive assessment of treatment outcomes.

The 21 point Cephalometric Severity Index

This index was developed in South Africa as a quantitative assessment of treatment severity cephalometrically. Hence, this index represents a series of five of the most important areas of cephalometric measurements representing malocclusion as a single score. Twenty one specific linear and angular skeletal and dental measurements as well as soft tissue measurements were identified. These measurements are most representative of a deviation from the norm in terms of treatment severity. Combining this with an occlusal index such as the Discrepancy Index would add more diagnostic value to the Index of treatment severity. It can also be used to assess the degree of improvement post-treatment as well as identifying deficiencies that can be corrected in the future. Unfortunately, no clinical outcomes relating to the use of this index are available in the current literature.[18]

The American Board of Orthodontics (ABO) Cast and Radiographic Examination (CRE)

The ABO developed the Objective Grading System (OGS), a method of assessing case difficulty as well as evaluating the outcomes and quality of treatment using the cast and radiographic examination (CRE).[10–13] A series of field tests were done from 1995 to 1998 and each test was an improvement on the previous method.[9] This led to the formulation of an accurate, unbiased assessment tool. The resultant refinement of the criteria upon which the standard for the successful completion of a case would be based, improved consistently.[9]

The aim of this assessment method was to enhance the standard of orthodontic treatment in the United States of America.[9] The American Board of Orthodontics was founded for this purpose in 1929. American registered Orthodontists who enroll and pass the Board Examination are awarded American Board certification. Diplomates of the ABO need to renew their certification every ten years by use of the Objective Grading System.[11,19] The ABO grading system provides candidates with assistance in choosing appropriate cases as well as a method of self-evaluation in order to identify their shortcomings and to improve their treatment outcomes as clinicians.[19]

The CRE utilizes dental casts and panoramic radiographs for the assessment of the quality of the treatment that has been provided by the orthodontist. There are eight criteria of occlusal characteristics used by the ABO CRE to assess treatment outcomes. These criteria are essential for the establishment of a stable and functional occlusion as well as ensuring that adequate aesthetics are achieved on completion of orthodontic treatment.

These criteria can be categorized into three specific areas:[9,14]

a) First order relationships (movement of teeth in the sagittal dimension as described by Tweed.[20]) which are assessed by tooth alignment and occlusal relationships, overjet, interproximal contacts and root angulation.
b) Second order relationships (vertical dimension) which are assessed by the alignment of marginal ridges of adjacent teeth, good occlusal contacts as well as root parallelism of the posterior teeth.
c) Third order relationships (torque) as assessed by the bucco-lingual inclination of the posterior teeth and the angulation of the anterior teeth.

Both anterior and posterior alignment of the teeth within their arches, with tight interproximal contacts void of any rotations are necessary in the attainment of good aesthetics as well providing a proper pathway for function.[11,21] The establishment of a good overjet will facilitate the harmonious functioning of the teeth, jaws and gnathology of the mouth.[22]

According to the ABO guidelines, if the marginal ridges of adjacent teeth are at the same level, the amelo-cemental junctions will also be at the correct level, resulting in a physiologically correct bone level between adjacent teeth. This relationship will facilitate the attainment of proper occlusal contacts and preserve periodontal health.[15] Proper occlusal contacts ensure adequate posterior occlusion which tends to create the attainment of maximum intercuspation.[22] Equal marginal ridge heights also imply that the roots of the posterior teeth are parallel.[15] It is important to establish root parallelism to enable the transmission of occlusal forces across the long axis of the tooth, as well avoiding possible relapse and preventing or minimising the risk of interdental bone loss as a result of root proximity also known as “kissing roots”.[11,21]

The bucco-lingual inclination of the maxillary posterior teeth should produce a gentle Curve of Monson which will result in proper occlusal function as a result of the good relationship between the buccal and lingual cusp heights of the posterior maxillary and mandibular teeth. The correct relationship between the buccal and lingual cusps of the posterior teeth will result in maximum intercuspation of the posterior teeth in centric occlusion. At the same time all balancing side interferences will be eliminated when eccentric lateral mandibular movements occur during mastication.[11,21] Correct angulation and overbite of the anterior teeth is an essential element for the establishment of a good functional occlusion. Simultaneously, correctly placed incisors will result in an aesthetic smile being achieved.[21]

The Difficulty Index (DI) was later developed to augment the CRE as an additional ABO assessment tool. It has been accepted as an objective, valid and reliable method of determining case complexity and difficulty.[11] The DI assists the practitioner to define mandatory objectives of treatment at the onset of treatment serving as a roadmap towards achieving a successful outcome.[23]

As a result of the CRE being limited to the assessment of occlusion, the ABO introduced the Case Management Form (CMF) as a pilot programme in 2002 to improve the method of case assessment. The CMF was implemented in 2006 as a means of case assessment.[13] The DI and the CRE have been incorporated into the CMF. The CMF allows the orthodontist to formulate the objectives of treatment as well as being able to assess the relationship of the sagittal, transverse and vertical dimensions of the cranio-facial structures. The CMF reflects how changes in growth may alter those relationships, by the use of acceptable cephalometric and panoramic radiographs as well as casts of the jaws and teeth.[15]

All of these critical assessments contribute towards refining the achievement of acceptable aesthetics, optimal function, periodontal health, and stability. With the use of these indices, clinicians are able to objectively quantify the treatment objectives required to deal with different malocclusions as well as to assess the efficacy of different treatment modalities.[9,11,24] Application of such an index would aid in the setting of orthodontic treatment goals and setting standards of excellence in orthodontic care.[24] Data relating to the degree of complexity and management of

treatment outcomes could assist with quality assurance of treatment, research, and practice management in orthodontics, thus improving the management of clinical outcomes. [24]

The ABO continually strives to update its method of assessment in line with current trends in research and new developments in treatment procedures in orthodontics. In accordance with the digital trend in orthodontics the ABO explored the use of digital models in 2013. The use of digital models was implemented as a method of assessing records in 2016.[25] Several studies have been done in order to ensure the validity and accuracy of these digital concepts.[26–29]

In February 2019, a new method of examining candidates for the ABO case based examination was implemented. This method was introduced in order to ensure that the orthodontist's knowledge, diagnostic and clinical abilities, as well as his/her critical thinking was assessed in a reliable, fair and valid manner.[30,31] According to the ABO, this method is "more accessible to a wider range of candidates and is in accordance with post graduate curricula."[30] The examination now entails a scenario based clinical examination. It comprises of six scenarios with a range of four to seven questions for each scenario. The scenarios are divided into four categories, that is; data gathering, treatment objectives and planning, treatment implementation and management as well as critical analysis and outcomes assessment.[31] Tools that were previously used in the assessment of treatment outcomes, namely the ABO CRE grading system as well as the CMF will still be incorporated into the updated method of assessment.[31]

Several studies have used the ABO method of assessment to evaluate treatment outcomes in graduate orthodontic programmes.[16,24,32–35] These studies concur that the ABO CRE grading system is still a current and versatile method of assessing treatment outcomes amongst various demographics across the world.[16,22–24,32–35]

In 2002, the University of Illinois compared the results of ABO board certified cases done prior to the implementation of the ABO CRE grading system to that of university cases done after the implementation of the ABO CRE grading system. It was found that only 38.9% of cases presented prior to the implementation of the

ABO CRE grading system as opposed to 78.6% of cases presented after the implementation of the ABO CRE grading system would pass applying the OGS CRE grading system.[32] Another study undertaken by Deguchi et al., compared the treatment outcomes between two universities using various indices.[24] The study concluded that the ABO grading system combined with the Comprehensive Clinical Assessment (CCA) provided the best approach in assessing treatment outcomes.[24]

The CCA is a post-treatment evaluation that was developed by the postgraduate orthodontic programme at Indiana University in 2004 as a supplementary assessment in order to augment the DI and the CRE. The aim of that evaluation was to provide a more thorough examination of the quality of orthodontic treatment. The CCA evaluates facial form, dental aesthetics, vertical control, arch forms, periodontal management, root structure preservation, and treatment efficiency which compares the level of clinical outcomes to active treatment time.[24]

Riolo and Vaden, in 2009 published two articles regarding the establishment of a standard of care in orthodontics.[36,37] This was done in an attempt to draw attention to the inherent need for the implementation of a standard of care in orthodontics in both the private and public sector. The authors stated that "quality of care implies the establishment of a standard which creates quantifiable guidelines for care. This standard of care would ideally be founded on a clinical and evidence based didactic audit in order to reach a consensus. These realistic standards would be the acceptable criteria which every clinician should strive to attain."[36,37]

In 2016, the University of Turkey used the ABO CRE as a method of assessing the quality of their postgraduate treatment outcomes as they found this method to be a reliable and precise method of assessment.[23] The study was done in an attempt to review one of the aims of postgraduate programmes, that being "the maintenance and development of optimal standards of patient care for clinical practice."[23] As a part of the study, the ABO grading system was introduced into the postgraduate orthodontic curriculum to empower postgraduate students with regard to their expectations of meeting specific criteria in order to achieve a more stable, functional and aesthetic treatment outcome. The study retrospectively compared results of

postgraduate students prior to the implementation of education regarding the ABO grading system to that of those exposed to the knowledge of the ABO grading system. It was found that those exposed to the concept displayed superior treatment outcomes when compared to those not exposed to the concept.[23]

The ABO method of assessment was also tested in China to investigate its applicability in the assessment of treatment outcomes in Chinese patients. The results were favourable as an assessment tool for the Chinese population.[34]

The first study assessing orthodontic treatment outcomes in South Africa was conducted in 2018 at the University of Witwatersrand (Wits).[33] It was done using the ABO CRE grading system. This study revealed that 76% of the cases scored less than 20 points, indicating an excellent outcome and 24% fell in to the category of greater than 20 but less than 25 points, indicative of a good outcome.[33]

Based on the studies above, there is sufficient evidence to validate the need for employing a method of assessing treatment outcomes in order to ensure that the optimal standard of care in orthodontics is achieved both in training institutions as well as in private practice. The ABO method of assessment has proven to be a reliable method of assessing treatment outcomes at these institutions as well as in private practice.[16,24,32,33,35]

Orthodontics was the first recognised dental specialty in the world.[38] It has been recognised as a specialty in South Africa since 1948.[39] The Schools of Oral Health Science in South Africa offer courses leading to specialisation in orthodontics, and the College of Medicine of South Africa (CMSA) sets examinations which are recognised by the HPCSA as an entry examination to the orthodontic speciality.
However it appears that there are no set standards nor a reference in the literature regarding:

a) The requirements for the presentation of examination cases for the Masters in Dentistry (Orthodontics) examination.
b) Agreed criteria for assessment of treatment outcomes of presented cases.
c) Quality control of treatment outcomes.

Statement of purpose

There are no clearly laid down standardised criteria for the assessment of treatment outcomes in South Africa. The aim of this study is therefore to assess the treatment outcomes of patients treated at Sefako Makgatho Health Sciences University (SMU) using the ABO CRE. This study was ancillary to a larger project, the objectives of which are to evaluate case complexity, treatment outcomes, as well as the variation in skills and teaching ability of registrars and consultants on the outcome of treatment in all four graduate orthodontic programmes in South Africa.

Aim and Objectives

Aim:

The aim of the study was to evaluate orthodontic treatment outcomes of patients managed at the postgraduate orthodontic clinic at SMU using the ABO CRE system.

Objectives:

1. To determine the CRE scores of orthodontic treatment outcomes of each completed case provided the required records of good quality were available.
2. To compare the CRE scores amongst registrars under the supervision of the same consultants.
3. To determine which factors may influence orthodontic treatment outcomes, for example, varying skills of registrars, the input of different consultants and gender of patients.

Chapter 2

Material and Methods

Study design

This was a retrospective, descriptive, cross sectional study. The study evaluated post-treatment records of patients treated to completion by registrars at SMU from 1 January 2011 to 31 December 2015.

The study period 2011-2015 represented the most recent intake of postgraduate orthodontic registrars who have graduated at SMU.

Sample setting

Post-treatment study models and radiographs which were obtained from SMU for the selected study period were considered. SMU is one of the four dental schools which train registrars in the orthodontic speciality. The selected study period corresponds with the four year training period of one cohort of registrars.

Sample size

All available and eligible post-treatment patient records of registrars enrolled during the selected study period were considered. There were four registrars enrolled at SMU during the selected study period. A total of 57 cases were available for assessment, of which only 49 cases met the inclusion criteria.

Inclusion criteria

Good quality records are essential.

Models:[40]

a) The correct anatomical detail of all teeth need to be captured.

b) There should be no defects or bubbles in the plaster.

c) There should be a wax bite that correctly captures the occlusion.

Panoramic x-ray:[40]

a) Adequate clarity is required to permit the formulation of a diagnosis.

b) Correct radiation exposure for a good resolution of the X-ray.

c) Good head positioning is essential.

Exclusion criteria

1. Patients with significant cranio-facial anomalies
    a) Cleft lip or cleft lip and palate
    b) Syndromic patients
2. Patients with missing/incomplete post-treatment records
3. Cases not treated to completion by the graduating class of 2015

CRE Measurements

The CRE value was obtained from the assessment and scoring of post-treatment models and panoramic radiographs.[10] The scoring was done according to the ABO guidelines by the use of the ABO measuring gauge.[10] These measurements were entered into the ABO CRE assessment forms (Appendix A) and the total was automatically calculated electronically.

The following CRE criteria were assessed:[10]

1. Alignment and Rotations
2. Marginal ridges
3. Bucco-lingual inclinations
4. Occlusal contacts
5. Occlusal relationships
6. Overjet
7. Interproximal Contacts
8. Root angulation

Figure 1 shows the ABO measuring gauge which has been fabricated by the American Board of Orthodontics to create an objective method of measurement.[10] The gauge has area markings A to D, which are explained in Table 1.[9]

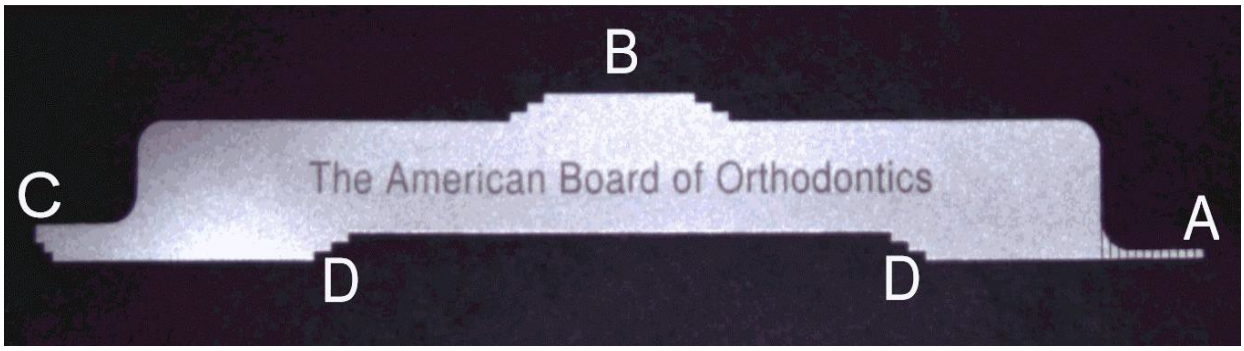


Figure 1: ABO measuring gauge

Table 1: ABO measuring gauge markings

AREA	CALIBRATION	EVALUATION
A	Increments of 1mm Width: 0.5mm	Discrepancies in alignment, overjet, occlusal contacts, interproximal contact and occlusal relationships
B	Steps: 1mm in height	Discrepancies in mandibular posterior bucco-lingual inclinations (Mandibular 3rd Order)
C	Steps: 1mm in height	Discrepancies in marginal ridges (2nd order)
D	Steps: 1mm in height	Maxillary posterior bucco-lingual inclinations (Maxillary 3rd order)

Table 2 encompasses a list and description of the criteria to be scored as well as the score per criteria.

Table 2: CRE criteria, their description and score

CRITERIA	DESCRIPTION[9–11]	SCORE[11]
Alignment	Horizontal evaluation of teeth **Anterior:** **Maxillary (Mx)** Incisal edges and lingual surfaces of teeth in alignment **Mandibular (Md)** Incisal edges and labial surfaces of teeth in alignment **Posterior:** **Mx:** Central grooves in alignment **Md:** Buccal cusps in alignment	Teeth all in alignment/ < 0.5mm= no points (pt) 0.5mm-1mm=1pt/ tooth > 1mm= 2 pts / tooth
Marginal ridges	**Vertical evaluation of teeth** All marginal ridges of adjacent posterior teeth should be at the same level	Each interproximal contact between posterior teeth: 0.5 -1 mm= 1 pt >1mm= 2 pt
Bucco-lingual inclinations	**Torque evaluation** No significant difference between heights of buccal and lingual cusps Md first premolars and distal cusps of second molars are not graded	0-1mm= no score 1-2mm=1pt/post tooth >2mm =2pt/post tooth
Occlusal contacts	**Assessment of functional cusps:** **Mx post teeth:** Lingual cusp **Md post teeth:** Buccal cusp Maximum intercuspation of opposing teeth Diminutive cusps excluded	≤ 1mm = 1 pt/ tooth >1mm = 2 pts/ tooth

CRITERIA	DESCRIPTION	SCORE
Occlusal relationships	Mx canine cusp tip lies between Md canine and adjacent premolar (+- 1mm range) Mesio-buccal cusp of Mx first molar should align within 1mm of mesio-buccal groove of Md first molar (Angle's Classification)[2]	<1mm = no score 1-2mm = 1 pt > 2mm = 2 pt
Overjet	**Assessment of labio-lingual relationship of Mx to Md arch** **Anteriorly**: Md incisors contact palatal surfaces of Mx anterior teeth **Posteriorly:** Md buccal cusps in central fossa of opposing Mx tooth	Articulate models, lie them flat on the back of models **Md buccal cusp:** 1mm/ less= 1pt > 1mm = 2 pts No more than 2 pts/ tooth
Interproximal spaces	**No interproximal spaces should be present.** Mesial of one surface contacts the distal surface of adjacent tooth	≤0,5mm space = no score > 0.5 – 1mm = 1 pt > 1mm = 2 pts No more than 2pts
Root angulation	Post-treatment panoramic x-ray used Roots must be parallel to each other Exclude canines for scoring	Roots parallel to each other and perpendicular to Md plane – no score Root mesial/ distal i.e. not parallel = 1 pt Root angled mesial/ distal, contacting adjacent tooth root = 2pts

Data analysis

Once compiled, the CRE scores were entered into Microsoft Excel © where the initial interpretation was done. The processed data was then uploaded into the Stata ® version 14 software[41] for descriptive and inferential statistical analysis.

The CRE data was stratified into the following categories:

Table 3: Stratification of CRE

CATEGORY	CRE SCORE	TREATMENT OUTCOME
Group A	Less than or equal to (LE)20	Excellent
Group B	Greater than (GT) 20 but LE 25	Good
Group C	Greater than 25 but LE 30	Satisfactory
Group D	Greater than 30	Unsatisfactory

The following analyses were used:

1. Descriptive measures:
   Calculation of the median and interquartile range as a result of the skewed measurement of the outcomes.
2. Fishers exact test:
   Compared the data amongst treated cases with regard to registrars, consultants, malocclusion, patient race and gender due to the small sample size. Confidence intervals of 95% were employed.
3. Multivariate regression analysis:
   Assessed the relationship between the variables of the CRE and the final CRE score.

Error of Method

The researcher has been trained by an ABO Diplomate to use the ABO CRE measurements.

1. Intra-examiner reliability:

   To assess error of measurement, ten sets of records were randomly selected and re-measured a week after the initial set of measurements. The measurements were calibrated through repeat measurements in order to standardise the primary investigator.

2. Inter-examiner reliability:

   Ten different sets of records were randomly selected and re-measured by another ABO CRE trained registrar. The measurements were also calibrated through repeat measurements in order to obtain consistency of measurements between the primary investigator and the ABO CRE trained registrar.

   The first and repeat measurements were compared using the kappa statistic.

   The intra-examiner reliability was found to be moderate and the inter-examiner reliability was fair. This could be attributed to the small sample size making statistical comparisons uncertain.

Ethical considerations

1. Permission

   This study does not involve direct patient contact. Ethical permission to conduct the study has already been obtained from the Wits Human Research Ethics Committee (M170117). (APPENDIX B) Individual ethics permission was also obtained from the Wits Human Research Ethics Committee. (M191014) (APPENDIX C). Ethical permission to conduct the study at SMU was obtained from SMU (APPENDIX D). Permission to access the records was granted from both the Chief Executive Officer of the school as well as the Head of the Orthodontic Department at SMU (APPENDIX E).

2. Confidentiality

None of the information relating to the patient, treating registrar and supervisor appeared in the data to be analysed nor will it appear in any published data. Thus, the data cannot be linked back to the patients, treating registrars or consultants. For purposes of confidentiality, codes were randomly allocated to the registrars and the supervisors. Numbers were allocated to each case. Only the primary researcher of the data had access to the coding and numbering.

Chapter 3

Results

A total of fifty seven cases were assessed. Eight cases did not meet the inclusion criteria and were excluded. A sample of forty nine cases was thus suitable for examination. These cases were treated by four registrars.

A median with interquartile ranges were used to represent the CRE score as the results were not normally distributed. The CRE score had a median of 43. This is below the acceptable CRE score, deeming these cases unsuccessful according to the ABO standards. The median age of patients in this study was 18 post-treatment. Females constituted 77.6% of the sample and males constituted 22.4%. The CRE for gender was not significant, (p=0.34). The distribution of the categories of malocclusion that were treated is represented in table four below. Class 1 malocclusion was the most frequent type of malocclusion (34.7%). The CRE for malocclusion was not significant, (p=0.20).

Table 4: Frequency and percentage distribution of Malocclusion

Malocclusion	CRE GROUP				Total	Percentage
	A	B	C	D		%
Class I	0	2	0	15	17	34.7
Class II	0	0	1	1	2	4.1
Class II Div 1	0	0	0	7	7	14.3
Class II Div 2	0	0	0	9	9	18.3
Class II sub L	0	0	0	2	2	4.1
Class III	0	0	0	7	7	14.3
Class III sub L	0	0	0	2	2	4.1
Class III sub R	0	0	1	2	3	6.1
Total (%)	0 (0)	2 (4.1)	2 (4.1)	45 (91.8)	49 (100)	100 (100)

Is there a difference in the CRE scores amongst the registrars?

The outcomes of the registrars were analysed using a sample of 49 cases. There were four registrars, each having a different number of patients (Table five). The Fisher's exact test showed a significant difference between the CRE and registrars, (p=0.000).

Table 5: Frequency and percentage distribution of CRE by Registrar

Registrar (Reg)	CRE GROUP				Total	Percentage
	A	B	C	D		%
Reg1	0	2	5	3	10	20
Reg2	0	0	1	11	12	24.5
Reg3	0	1	0	14	15	31
Reg4	0	0	0	12	12	24.5
Total	0	3	6	40	49	100

(p<0.05)

Is there a difference in the CRE scores amongst the consultants?

The outcomes of the consultants were analysed using a sample of 49 cases. There were three consultants, each supervising a different number of students (Table six). The Fisher's exact test showed no significant difference, (p =0.083).

Table 6: Frequency and percentage distribution of CRE by Consultant

Consultant (Cons)	CRE GROUP				Total	Percentage
	A	B	C	D		%
Cons 1	0	0	2	22	24	49
Cons 2	0	2	4	17	23	47
Cons 3	0	1	0	1	2	4
Total	0	3	6	40	49	100

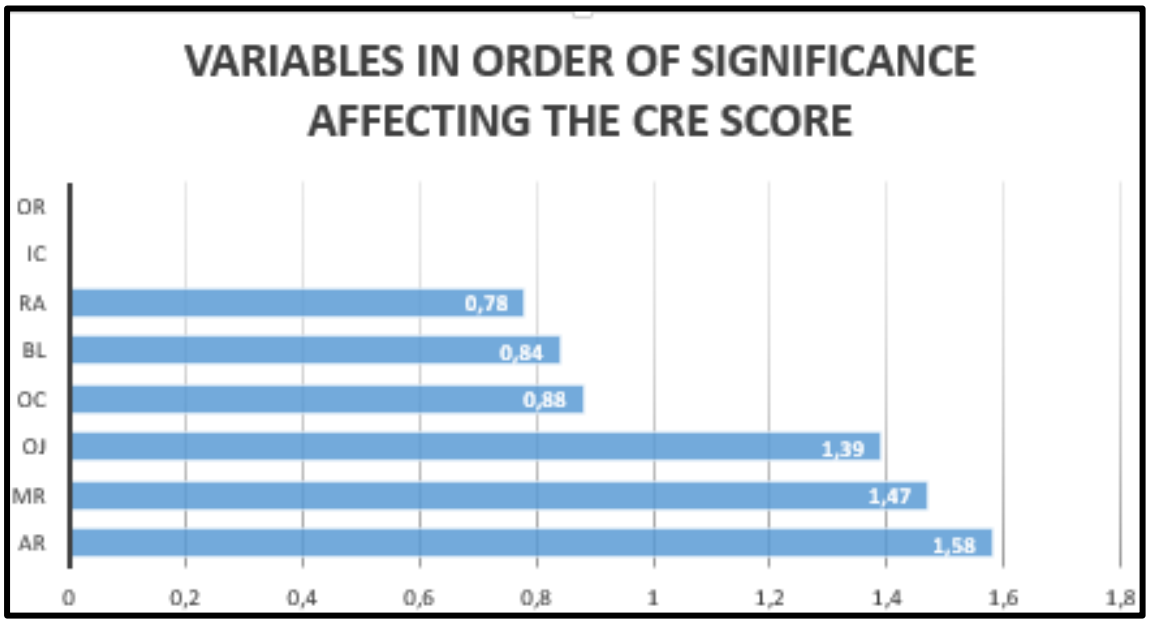
(*p<0.05*)

Table 7: Multivariate analysis of variables on the CRE

CRE	Coef.	Standard Error	95% Confidence Interval	
Alignment and Rotations (AR)	1.58	.17	1.2	1.93
Marginal Ridges (MR)	1.47	.15	1.17	1.78
Overjet (OJ)	1.39	.22	.93	1.84
Occlusal contacts (OC)	.88	.21	.44	1.31
Bucco-lingual inclinations (BL)	.84	.12	.58	1.09
Root angulation (RA)	.78	.20	.37	1.20

Table seven above and table eight below show several variables displaying a statistical significance, with a 95% confidence interval. Alignment and rotations are found to be the most deficient component followed in descending order by Marginal Ridges, Overjet, Occlusal Contacts, Bucco-lingual inclinations and lastly Root Angulation. Interproximal contacts and occlusion relations were not clinically significant. This is more clearly illustrated in order of significance in table eight below.

Table 8: Variables of the CRE in descending order of significance of scoring



AR- Alignment/Rotations

OJ- Overjet

BL- Bucco-lingual Inclinations

IC- Interproximal Contacts

MR-Marginal Ridges

OC-Occlusal Contacts

RA-Root Angulations

OR-Occlusal Relations

The distribution of the consultants to registrars as well as the poorly documented information did not allow for the accurate capturing and comparison of the CRE of registrars and the consultants. The sample size also did not allow for the accurate comparison between gender and race of the patients. These comparisons were thus omitted from the study.

Chapter 4

Discussion

The ABO assessment of treatment outcomes is a valuable tool for self-evaluation. A number of dental schools throughout the world have been using this assessment to give post-graduate orthodontic students a better understanding of what is required to produce excellent orthodontic outcomes as well as objectively assessing the results of post graduate students for examination purposes. This retrospective, descriptive study assessed the treatment outcomes at SMU according to the ABO CRE method of measuring orthodontic outcomes of treatment. Forty nine cases were examined. The small sample size can be attributed to non-completion of cases, poor record keeping as well as the stringent inclusion requirements of the ABO.[32]

It is interesting to note that 81.6% of the cases analysed fell in the category of greater than 30 which indicates a poor result in terms of the ABO method of assessment. Only 12% of cases indicated satisfactory results which were greater than 25 but less than 30 while 6% of cases examined were well treated, falling in the category greater than 20 but less than 25. A score of less than 20 is considered excellent by ABO standards of assessment. No cases achieved this result.

In reviewing these outcomes it is necessary to consider the fact that the students were unaware that their cases would be used in this study. They were not trained according to the ABO standards; thus they had no knowledge of the ABO CRE assessment. Several studies can attest to the fact that the implementation of protocols and assessments regarding treatment outcomes as well as exposure to set standards of care can enhance treatment outcomes significantly.[16,22,32,42,43]

The study by Yang and Powers in 2002 showed that only 19.6% of cases would have passed the ABO examination which is very similar to the outcome of the present study. The study also revealed that even experienced clinicians that had not attended a university which adhered to the ABO CRE standards in both clinical training and examination scored 40% more in terms of treatment outcome scores than those who had been exposed to ABO CRE standards during their orthodontic training. [32]

Deguchi et al., in 2005, found that only 45.1% of graduates from Okayama University and 46.6% of graduates from Indiana University would have passed the ABO examination.[24]

The outcome could also be associated with the lack of experience on the part of the graduates as compared to experienced orthodontists which was highlighted in the study by Yang and Powers in 2002. The experienced orthodontists had a 46.9% pass rate as compared to the students with a 19.6% pass rate. [32] Chalabi et al., retrospectively evaluated the treatment outcomes of graduates from Buffalo University in 2015 using the ABO CRE as well as the PAR Index. The results showed that only 38% of students would have passed if the ABO standards were applied.[14]

The study done at the University of Indianapolis by Pinskaya et al., from 1998 to 2000 assessed treatment outcomes using the ABO CRE and the CCA.[44] It showed a pass rate of only 39.6% using the CRE method of case assessment. This served as a baseline for the follow up by Knierim et al., in 2006. This study assessed treatment outcomes during the period of 2000-2003. The follow up study illustrates the benefits of being exposed to a method of assessing treatment outcomes as well as being exposed to the teaching regarding common deficiencies of the occlusion and their correction. This study was as done subsequent to a change in teaching protocols upon reviewing the results of the baseline of the study.[44]

The clinical protocol was instituted in accordance with the rectification of deficiencies found in the baseline study. The first change was educating new students to the deficiencies of the previous groups as well as instilling methods of rectifying these deficiencies. The second change entailed taking records and analysing pre-finishing records six months prior to the completion of treatment. Recementation of bands as well as bracket repositioning was then prescribed accordingly. In the study, this method was favoured over the placement of compensatory bends in arch wires for the correction of discrepancies at a later stage. The third change was to institute more frequent reviews of the case during treatment so as to note deficiencies as early as possible, thus allowing for the expeditious correction thereof.[16,44] The subsequent evaluation after the implementation of this clinical protocol showed an

improvement from 39.6% to 76.6% of cases being eligible to pass the ABO examination.[16,44] This study provides valuable input as to enhancing treatment outcomes found in the present study.

The study done at Wits showed a more favourable outcome. The study revealed that 76% of the cases scored less than 20 points, indicating an excellent outcome and 24% fell in to the category of greater than 20 but less than 25 points, indicative of a good outcome. The general goal of registrars in this sample was generally to satisfy Andrew's six keys of occlusion which also makes up part of the foundation of the ABO criteria.[3,4,33]

The Fisher's exact test showed an association between the CRE scores and the different registrars (p=0.000). One needs to be cautious in the interpretation thereof due to the uneven distribution of patients amongst registrars as well as the small sample size which comprised the study. The Fisher's exact test did not show an association between the CRE scores and the consultants, (p=0.083). These results are both in keeping with the study done at Wits.[33]

Identifying and correcting areas of deficiency generally leads to improved treatment outcomes. [16,22,33,42,43] Thus the ABO criteria were reviewed to identify the strengths and deficiencies. In this study, the multiple linear regression analysis revealed that the interproximal contacts as well as occlusal relations were not significant factors. The ABO field test[9], the university studies done by Yang and Powers, Knierim et al., as well as the Wits study concurred that interproximal contacts were not significant, indicating competence in space closure.[40,41]

Alignment and rotations were the most significant contributory component adding to the CRE score, followed in descending order by marginal ridges, overjet, occlusal contacts, bucco-lingual inclinations and root angulations. This is in keeping with other studies which identified overjet, marginal ridges, occlusal contacts, as well as bucco-lingual inclinations to be deficient components.[16,22,32,33,42,43,45,46] Unlike other studies, occlusal relations were not significant in this study.

The most significant factors, alignment and rotations, could be enhanced with experience.[32] Vagdevi et al., described alignment as a fundamental objective of any orthodontic treatment plan.[22] A properly aligned occlusion, devoid of rotations ensures a good aesthetic result as well as proper functioning of the dentition.[11,21] For correct anterior alignment, the incisal edges and lingual incisal surfaces of the maxillary incisors and canines, and the incisal edges and labial incisal surfaces of the mandibular incisors and canines have to align. Posteriorly, the mesio-buccal and disto-buccal cusps of the mandibular molars and premolars should be in the same mesio-distal alignment. The central grooves should all be in alignment in the maxillary arch.[11,22] Thus, with experience, the intricacies involved in the art of finishing a case can be enhanced as clinicians develop the necessary skillset and experience.

In this study, overjet was a significant factor. The establishment of a good overjet will facilitate the harmonious functioning of the teeth, jaws and gnathological function of the occlusion.[22] A contributing factor to the deficiency in overjet correction in this study could be attributed to the frequent observation of a tooth size discrepancy that was noted in many of the cases. This affected upper lateral incisors as well as lower premolars. Proffit et al., in 2000, described a tooth size discrepancy as “a disproportion among the sizes of individual teeth.”[47] Smith et al., emphasized that in order to achieve proper interdigitation, overjet and overbite on completion of treatment, there needs to be proportional dimensional relationships between the maxillary and mandibular teeth. In their study, the anterior ratio was statistically significant in blacks (79.3%).[48] A South African study by Hlongwa et al., highlighted the relevance of the anterior ratio when assessing and planning aesthetic alignment of the anterior segment. However, their study did not show a statistical significance in the anterior Bolton ratio.[49]

In the study by Yang and Powers, occlusal contacts scored higher among the more experienced clinicians whereas university candidates fared better in these categories. This was attributed to the awareness by experienced clinicians of the settling of occlusion directly enhancing these factors over time. Enhanced overjet correction in the more experienced group was also linked to more clinical experience. This study showed overjet and occlusal contacts to be of significance.

Knierim et al., found that occlusal contacts may be influenced by occlusal relationships and bucco-lingual inclinations.[16] The study by Neoh et al. revealed that deficiencies in occlusal contacts could be due to non-harmonised bucco-lingual inclination transversely, infraocclusion and excessive mesio-distal crown tip.[50]
Yang and Powers attributed improper bucco-lingual inclinations to inadequate torque control of the buccal segments. This was either due to a difficulty in identifying the problem, lack of ability to correct the problem or the use of pre-torqued brackets which do not have the correct torque necessary for finishing.[32] Yang and Powers also found that either insufficient lingual root torque or too much buccal root torque of posterior teeth was identified in both arches. In this study, it was noted that the second upper molars had the most deficient torque correction, displaying a general lack of sufficient buccal crown torque. In comparison, orthodontists featured less strongly in this component compared to postgraduate students.[32] In the study by Knierim et al., bucco-lingual (third order) inclinations also proved to be a challenging factor. The study by Net et al., concurred with this finding that post treatment settling is not as beneficial in the correction of bucco-lingual inclinations.[45] Being the second highest on Knierim et al's list of deficiencies, it was found that mandibular bucco-lingual discrepancies corrected better over time compared to maxillary bucco-lingual discrepancies.[16]

Deguchi et al., found that most discrepancies involved second permanent molars. They attributed these shortcomings to the second molars being banded later in treatment, possibly corresponding with patient fatigue and their persistence in the removal of their braces by this stage. Another interesting correlation between their study and this study would be the short anterior cranial base and decreased maxillary lengths generally identified in both Japanese patients as well black patients.[51] The short anterior cranial base has been associated with decreased facial height and width.[24] The sample in this study consisted mainly of black patients. This finding would contribute to the explanation of poor finishing of the maxillary and mandibular second molars.[24]

Marginal ridges were also identified as being deficient. Proper alignment of marginal ridges is an indication of proper occlusal alignment as well as adequate root

parallelism. These factors would facilitate the attainment of maximum intercuspation.[22] Root parallelism allows for the transmission of occlusal forces across the long axis of the tooth, enhancing long term stability as well as minimising the risk of periodontal problems due the root proximity.[11,21]

Yang and Powers found that root parallelism was better in the university group as this was included in the ABO CRE grading. Experienced clinicians may tend to overlook this problem as long as the clinical outcome is satisfactory. Studies suggest that an orthodontist should aim for the best possible finish and not rely on the settling of occlusion to enhance the overall long-term outcome.[32,33] Both the study by the ABO as well as the study by Neoh et al., found that the maxillary lateral incisors, canines, second premolars, and mandibular first premolars were the most deficient in terms of root parallelism.

Bouwens et al., suggested that one should exercise caution when assessing mesio-distal root angulations in panoramic radiographs. A thorough clinical examination of the dentition should also be executed.[52] Neoh et al., stated that root angulation discrepancies could be attributed to insufficient bucco-lingual inclination, mesio-distal tipping or the inadequate correction of rotations of teeth.[50]

Another reason for several factors being deficient could be attributed to records being taken on the same day of debonding, thus not allowing for the settling of the occlusion that occurs thereafter. This may be necessary in a university setting as patients may not return for follow up records.[44] The ABO cases can be submitted a year post treatment thus allowing for certain components of occlusion to settle over time.[9] The settling of occlusion over time has been well documented in the literature.[16,22,33,45,50,53,54] The only component that worsened over time was the alignment and rotations.[45]

Chapter 5

Summary and conclusion

The assessment of treatment outcomes allows one to self-evaluate your own ability. It is necessary to recognise factors that achieve good results as well as identifying any shortcomings of treatment rendered in an effort to aid in the improvement of the standard of care both as a student as well as a qualified practitioner.

The summary of the study are as follows:

1. 81.6% scored in the category GT30 indicating an unsuccessful result by ABO standards. 12% scored a satisfactory result of GT25-LE 30, 6% scored a good result of GT20-LE25 and none scored in the excellent category of LE20.
2. There was an association between the CRE scores and the registrars, (p=0.00).
3. There was no association between the CRE scores and the consultants, (*p*=0.083), between the CRE scores and gender (p=0.34) or between the type of malocclusion and the CRE (p=0.20).
4. The most deficient component of the CRE was Alignment and Rotations, followed closely by Marginal Ridges and Overjet. Interproximal contacts as well as Occlusal Relations were not significant factors contributing to the CRE score.

The outcomes of this study reinforce the need for post graduate orthodontic training programmes within South Africa to implement a standardized method of establishing and assessing treatment outcomes. This should be integrated into the curriculum at the onset of teaching. It would serve as guidance towards achieving an improvement in the overall quality of orthodontic treatment. It is our recommendation that the ABO CRE method of assessing treatment outcomes be considered as it ensures that an aesthetic, functional and stable occlusion is achieved.[9,11,23]

Limitations and recommendations

1. A relatively small sample size was available, thus certain parameters within this study could not be properly assessed as a true representation of treatment outcomes at SMU.

   1.1 Academic institutions should be encouraged to execute more stringent methods of clinical record keeping. This would aid in the efficiency and accuracy of research.

   1.2 The digitisation of orthodontic models and records should be instituted across academic institutions in South Africa. The data could then be archived online to facilitate storage and ease of access.

2. The higher CRE scores allow for follow up studies to be conducted:

   2.1 The implementation of a method of assessing treatment outcome should be introduced into the curriculum so as to create a better standard of care. The deficiencies identified in treatment outcomes should be highlighted to future students to improve upon the existing standards. A follow up study can be done to compare the treatment outcomes prior to and subsequent to the implementation of the assessment tool.

   2.2 The re-evaluation of the stability of the cases reviewed in this study after settling has occurred can be done.

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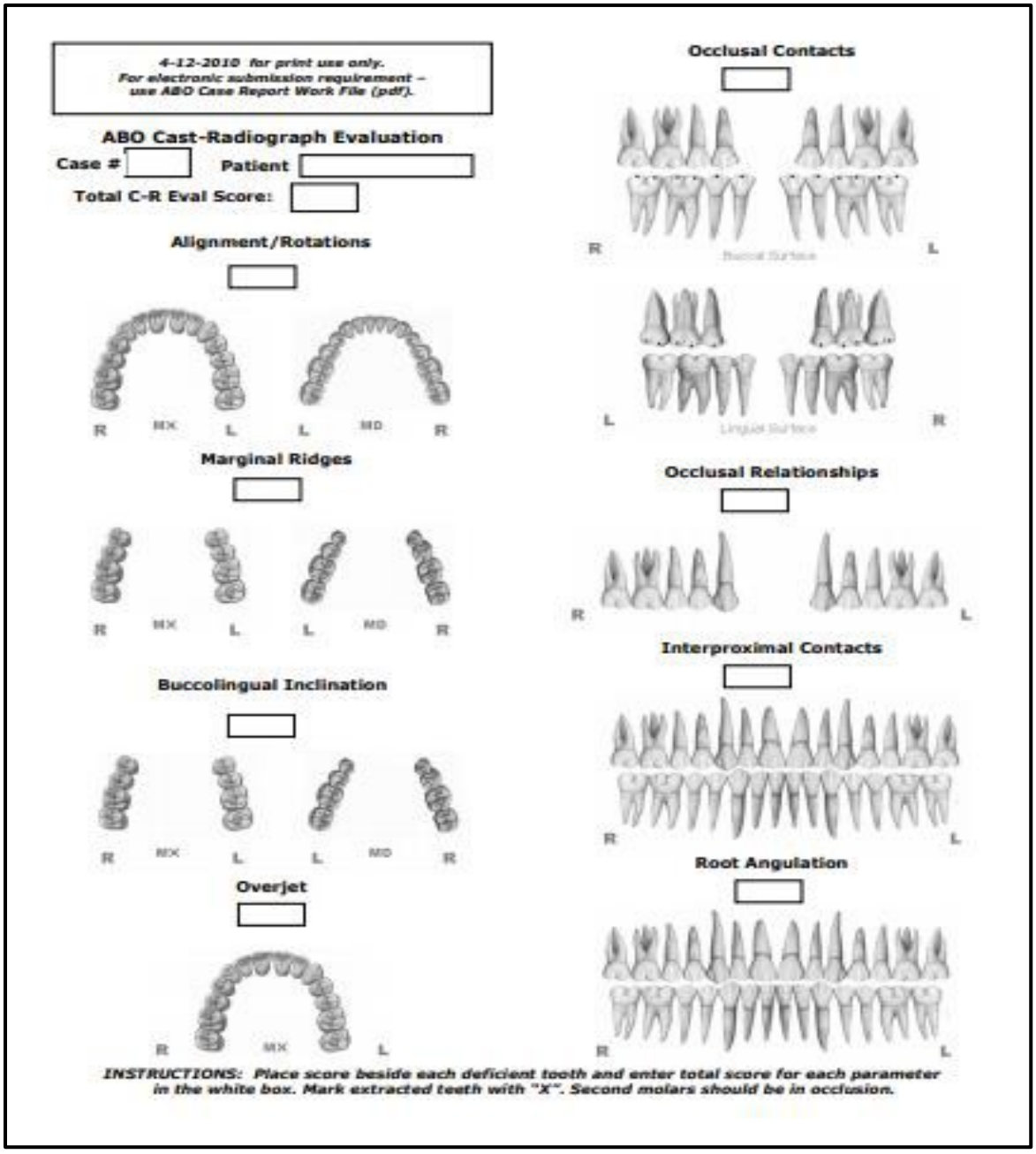
Appendices

Appendix A: Cast and Radiograph evaluation form[11]



Alignment	First Order (horizontal) alignment of teeth
Marginal ridges	Second Order (vertical) alignment of teeth
Bucco-lingual inclination	Third Order positions of the molars
Overjet	Buccal and anterior segments

Appendix B: Umbrella Ethical Clearance Certificate

R14/49 «Tit init name»

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M170117

NAME: (Principal Investigator)	Prof Tarisai C Dandajena et al
DEPARTMENT:	Orthodontics and Paediatric Dentistry Witwatersrand, Pretoria, Western Cape, Sefako Makgatho Oral Health Centre Universities
PROJECT TITLE:	Evaluation of Treatment Outcomes in Graduate Orthodontics Programmes in South Africa using the American Board of Orthondotics (ABO) Cast and Radiographic Examination (CRE)
DATE CONSIDERED:	27/01/2017
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	
APPROVED BY:	Professor P. Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	12/05/2017

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand. I/We fully understand the the conditions under which I am/we are authorised to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. in this case, the study was initially review in January and will therefore be due in the month of January each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature Date 2017/5/16

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix C: Individual Ethics Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R14/49 Dr M Rangan

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M191014

NAME: (Principal Investigator)	Dr M Rangan
DEPARTMENT:	School of Oral Health Sciences Department of Orthodontics Dental School University
PROJECT TITLE:	Evaluation of treatment outcomes in the graduate orthodontic clinic at Sefako Makgatho University, using the American Board of Orthodontics Cast and Radiographic Examination
DATE CONSIDERED:	2019/10/25
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Professor S Chertkow and Dr Moshaoa
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2020/02/24

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and ONE COPY returned to the Research Office Secretary on the 3rd Floor, Philip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.
I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report.** When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in October and will therefore reports and re-certification will be due early in the month of October each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

26/02/2020
Date

PLEASE QUOTE THE CLEARANCE CERTIFICATE NUMBER IN ALL ENQUIRIES

Appendix D: Ethics Clearance Certificate from SMU

SEFAKO MAKGATHO
HEALTH SCIENCES UNIVERSITY

Postgraduate Studies, Research Development, Integrity & Ethics
Sefako Makgatho University Research Ethics Committee (SMUREC)

Dr MV Rangan
University of the Witwatersrand

Dear Dr Rangan

RE: PERMISSION TO UTILIZE RECORDS OF ORTHODONTIC PATIENTS TREATED AT SEFAKO MAKGATHO HEALTH SCIENCES UNIVERSITY ORAL AND DENTAL HOSPITAL

SMUREC **NOTED** your letter requesting permission to utilize records of orthodontic patients treated at Sefako Makgatho University Oral Health Centre (SMU-OHC).

SMUREC **NOTED** that the researcher has already received unconditional approval from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand.

Study Title:	Evaluation of treatment outcomes in the graduate orthodontic clinic at Sefako Makgatho Health Sciences University using the American Board of Orthodontics Cast and Radiographic Examination
Researcher:	Dr MV Rangan
Supervisor:	Prof SI Chertkow Dr MLA Moshaoa
University:	University of the Witwatersrand
Research Type:	Master of Dentistry - Orthodontics
Ethics Approval Ref:	M170117

SMUREC **APPROVED** the request and provided permission to collect data at SMU. A letter of approval from the CEO of the SMU Oral Health Centre is attached.

Yours Sincerely,

PROF C BAKER
CHAIRPERSON SMUREC

07 November 2019

SEFAKO MAKGATHO
HEALTH SCIENCES UNIVERSITY
SMU Research Ethics Committee
Chairperson
Date: 07 November 2019

Molotlegi Street, Ga-Rankuwa
Pretoria, Gauteng
PO Box 163, Medunsa, 0204
www.smu.ac.za

Telephone: +27 12 521 5617 / 3698
Facsimile: +27 12 521 3749
Email: kirato.phiri@smu.ac.za

Appendix E: Permission to Access Records at SMU

GAUTENG PROVINCE

GAUTENG PROVINCE
REPUBLIC of SOUTH AFRICA

Office of the CEO: SMU OHC
Enquiries: Prof SJH Hendricks
Tel: (012) 529 4801
Email:Stephen.hendricks@smu.ac.za
:winile.mambana@smu.ac.za

11 February 2020

Dear Dr MV Rangan

PERMISSION TO CONDUCT RESEARCH

The SMU-Oral Health Centre/School of Oral Health Sciences hereby grants you permission to conduct research entitled:

Evaluation of treatment outcomes in the graduate orthodontic clinic at Sefako Makgatho Health Sciences University using the American Board of Orthodontics Cast and Radiographic Examination

This permission is granted subject to the following conditions:

- That you obtain Ethical clearance from the Human Research Ethics Committee of the relevant University. ☑
- That the Institution incurs no cost in the course of your research ☑
- That access to the staff and patients at the SMU-OHC will not interrupt the daily provision of services. ☑
- That prior to conducting the research you will liaise with the supervisors of the relevant sections to introduce yourself (with this letter) and to make arrangements with them in a manner that is convenient to the sections. ☑
- Formal written feedback on research outcomes must be given to the Director: Clinical Services ☑
- Permission for publication of research must be obtained from the Chief Executive Officer ☑

Yours sincerely

Prof SJH Hendricks

Dean/CEO: SMU-OHC
DATE: 12/2/2020

APPENDIX F: Turnitin Report

a0046871:rangan_turnitin.docx

ORIGINALITY REPORT

6%	2%	2%	7%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to University of Witwatersrand Student Paper	4%
2	www.americanboardortho.com Internet Source	2%

Exclude quotes	On	Exclude matches	< 100 words
Exclude bibliography	On		

APPENDIX G: Examiners Report

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG | FACULTY OF HEALTH SCIENCES

CERTIFICATE OF SUBMISSION FOR EXAMINATION SIGNED BY SUPERVISORS OF HIGHER DEGREES CANDIDATES

Full name	Mathuraya Rangan		
Student number	762643		
Candidate for the degree of: MDENT *has submitted his/her thesis/dissertation/research report* Entitled: **Evaluation of treatment outcomes in the graduate orthodontic clinic at Sefako Makgatho University using the American Board of Orthodontics Cast and Radiographic Examination**			
Contact no	0832273341	E-mail	mathuraya.rangan@wits.ac.za

Mark with an X on appropriate box	Yes	No
Has this thesis/dissertation/research report been submitted with the acquiescence of the supervisor?	X	
To the best of your knowledge are you able to verify that this is the candidate's work, except as otherwise stated by the candidate?	X	
The substance (nor any part of it) has not been submitted in the past nor is being submitted for a degree in any other university?	X	
The candidate has acknowledged wherever any information used in the thesis, dissertation or other work has been obtained by him/her while employed by, or working under the aegis of, any person or organization other than the University or its associated institutions?	X	
Have examiners been nominated and approved?		

I certify that this thesis/dissertation/research report has the approval of the Animal Ethics Committee / Committee for Research on Human Subjects and the Number of the Certificate of Approval is:

_____

List all publications, which your student has published in peer-reviewed journals from his/her postgraduate research report/dissertation/thesis during the course of his/her studies in the Faculty of Health Sciences (Include authors, year, title of paper, name of journal, volume number and page numbers). This information is mandatory.
None

Name of Supervisor 1: Professor SI Chertkow

Telephone: 0828529888 Email: chertkow@global.co.za

Signature: _____ Date: 17-04-2020

Name of Supervisor 2: Dr MLA Moshaca

Telephone: 0769546611 Email: lera.moshaca@yahoo.com

Signature: _____ Date: 17/04/2020

IMPORTANT NOTICE WITH REGARD TO THE SENATE STANDING ORDERS:

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